**Question 1:**

*Dear Cheap Astronomy – Is there any point in 'Nuking Mars'?*

In a word, no. The idea, famously championed by Elon Musk is that we should drop thermonuclear bombs on Mars poles' , releasing large volumes of water vapour and carbon dioxide, which will bulk out Mars exceedingly thin atmosphere – and since both water and $CO_2$ are greenhouse gases they should warm up the planet.

Bits of this could work, at least in the short term. Nuclear bomb would melt the ice and the gases formed would then become atmosphere. But you would need quite a few nuclear bombs to melt the entirety of each cap, The larger northern ice cap is about 1100 km in diameter, the smaller southern one is about 400 kilometres in diameter. The permanent base of each cap is water ice, up to 3 km thick. Each winter a layer of frozen carbon dioxide is added onto those ice caps, which at mid-winter represents up to a third of Mars total $CO_2$ dominated atmosphere.

The idea of terraforming Mars is compelling. It's a planet with a similar spin to Earths, 24 hours and 27 minutes and it has a similar axial tilt, 25 degrees versus Earth's 23.5 degrees. So, like Earth, seasons arise from that axial tilt and, like Earth, one hemisphere's winter is the other hemisphere's summer. So, winter in the northern hemisphere is freezing out $CO_2$ from the atmosphere while summer in the southern hemisphere is returning $CO_2$ to the atmosphere.

So, if we undertook a Musk Nuke Mars campaign, you might increase the atmosphere's $CO_2$ density by a third, which is a big proportional change, but let's remember this is an atmosphere with about one percent of the earth's atmospheric density, so that much additional $CO_2$ is not actually going to have that much greenhouse impact. After all, it's mostly $CO_2$ that is routinely being released and recaptured on a seasonal basis anyway.

The bigger impact from nuking Mars will come from vapourising the main volume of Mars' ice caps, which is water. Water vapour is a very potent greenhouse gas and the low atmospheric pressure of Mars should prevent it from settling on the surface as a liquid. But Mars' greater distance from the Sun means there's just not that much solar flux, so there's just not as much heat that can be trapped by the greenhouse effect, compared to Earth or Venus – and within a day of dropping the nukes, the poles will have cooled back down and will start freezing out water from the atmosphere again.

You also have the issue of Mars having no magnetic field so solar wind will be irretrievably stripping away water vapour from the upper layers of the atmosphere, an effect that will inexorably continue as long as water remains in the atmosphere in gaseous form. Elon Musk has suggested that once there's sufficient greenhouse gases in the atmosphere this should start a positive feedback loop where volatiles are heated out of the regolith across the planet, which all add to the atmosphere and hence add to the heating. But, while this certainly happens on Venus, Mars gets a lot less sunlight and it's got less gravity to generate an atmospheric pressure than Venus.

So, nah, it just doesn't work. Mars is an old, stable planet that's at equilibrium with itself. Drop some bombs and you can shift that equilibrium for a while, but unless you keep on dropping those bombs continuously, the planet will inevitably trend back to its earlier equilibrium state. The whole problem with climate change on Earth, is that we keep on burning more coal and cutting down more forests. If we stopped it all tomorrow the climate would slowly trend back to how it was before the industrial revolution.

Mars is a low solar flux, low gravity planet with virtually no magnetic field. If you really want to terraform it, those are the issues that you have deal with. And really, the water ice polar caps will probably work out to be a useful resource for future spacefarers, so it's best left intact and un-nuked

**Question 2:**

*Dear Cheap Astronomy – How are we going to launch from Mars*

Sorry we can't seem to get off doing podcasts about Mars lately – and that is the topic of today's podcast. How can we get off Mars? Getting something onto the surface of Mars in one piece is a major technical challenge. Getting something off the surface in a controlled fashion is a whole different story. This is not something we have achieved to date with robots and doing it with astronauts will be a couple of orders of magnitude more difficult.

Calculating how you land on Mars is a bit like calculating Tsiolkovsky's rocket equation in reverse. There's almost no atmosphere on Mars, well maybe enough that you can achieve a small slow down with a heat shield aerobraking and a parachute, but to land any sizeable mass safely on the surface you also need retro rockets – and the bigger the mass you want to land, the more retro rocket burning you'll need– and the more retro rocket burning you need the more fuel you'll need to do it with and that more fuel means more mass, so you'll need even more fuel to decelerate the fuel that you need to decelerate with and so on and so forth.

So, the idea that you can not only land people on Mars, with their life support systems and all that, but also land them on Mars carrying enough additional fuel to allow them to take off again – well, forget it. It worked on the Moon because we had less gravity to contend with. Maybe we can do it with a pint-size launcher that's capable of returning a few small core samples collected the Mars 2020 rover, but even that's just an idea at the moment. So, if you really needed yet another reason why we aren't going to land people on Mars and return them safely back to Earth any time soon – there you go.

Although, to be fair to everyone who's thought this through, there is a way, but it involves a whole bunch of untested technologies, which is a polite way of saying it involves science fiction, although it is fairly-plausible science fiction, involving plausibly feasible technical solutions – at least they're plausibly feasible technical solutions on paper.

So, there is strong consensus amongst everyone that has thought all this through, that a MAV, a Mars Ascent Vehicle, will have to create its own ascent fuel from resources available on Mars.

Making fuel on Mars probably means making methane for the fuel plus liquid oxygen to burn the fuel. Although $CO_2$ can get you carbon and oxygen, you'll also need water to get the hydrogen in methane. Essentially you put $CO_2$ and water together to create methane and molecular oxygen, a reaction that requires energy, which you can get from solar panels.

It’s estimated you’ll need around 7 kilograms of fuel for every kilogram of launch payload and let’s remember Mars’ atmosphere is very thin so it’ll take a long time to extract all the $CO_2$ you need and of course, you can’t get water from the atmosphere and it’s unlikely you could extract enough water by digging or drilling within the immediate environs of the MAV. Of course, you could land a MAV near the poles and then access huge amounts of water, but you’d lose the momentum advantage of launching near the equator and you be landing on a surface that melts and refreezes over the course of a Martian year, so there’s all sorts of problems with that idea.

So to fuel the MAV, you would almost certainly have to bring water to the MAV. So you’ll need digging, drilling and extraction robots and some kind of long distance transport system – all of which is still technically feasible, but you’re now talking major infrastructure that has to be flown in and constructed ahead of the MAV, which itself has to be flown in well ahead of the astronauts. And of course nothing can go wrong with any of this because once the astronauts land, they’re stuck unless that MAV that they’ve never seen, let alone test-flown before, can really launch.

So, the chances of seeing boot prints on red regolith in the 2030’s look very slim. The first MAV will almost certainly be a robot bringing back rock samples – and for that much the 2030s does sound plausible.